REMARKS

Claims 1-3 have been rejected by the Examiner under 35 USC 102(b) as being anticipated by Tarumi et al., U.S. Patent 5,837,774 or under 35 USC 102(e) as being anticipated by Yamaguchi et al., U.S. Patent 6,673,887B2. Also, claims 4-7 have been rejected by the Examiner under 35 USC 103(a) as being unpatentable over Tarumi, Yamaguchi and Chaouk et al., U.S. Patent 6,160,030 in combination. These rejections are respectfully traversed.

The present invention is directed to a cross-linkable compound comprising a perfluoro polyether (PFPE) moiety which is ultimately terminated by an oxygen atom and bounded through a spacer attached to the oxygen atom with an ethylenically unsaturated group. The perfluoro polyether (PFPE) oil that can be used for making perfluoro polyether rubbers are particularly suitable for use in top layers of apparatus for transferring a toner image from an image-forming medium to a receiving medium, while preserving their non-sticky properties for a much longer period of time at elevated temperatures. According to the present invention, it has been surprisingly found that such suitable rubbers having good visco-elastic properties, including high elasticity and low compression set, can be obtained with the above cross-linkable compounds when the spacer extends over at least three atoms between the oxygen atom and the ethylenically unsaturated group. Thus, the distance between the oxygen atom which terminates the compound comprising the PFPE-moiety and the ethylenically unsaturated group involves at least three atoms in a row. As a result, good monomers for providing suitable rubbers can be obtained.

More specifically, claim 1 can be broken down into the following main features:

A cross-linkable compound comprising:

1) a perfluoropolyether (PFPE) moiety which is ultimately terminated by an oxygen atom and bonded through

2) a non-oxygen containing spacer attached to the said oxygen atom, wherein the spacer extends over at least three atoms between the oxygen atom and the ethylenically unsaturated group with an

3) ethylenically unsaturated group.

The general formula in claim 4 is D-$(C_nF_{2n}O)_m$-Q-B-A. Without considering the further limitations of claim 4, the features of claim 1 can also be represented with the general formula as follows:

1) **PFPE Moiety = D-$(C_nF_{2n}O)_m$-Q-** {note: in case D = A-B-Q-O- [see claim 4], the PFPE moiety is represented by –Q-O-$(C_nF_{2n}O)_m$-Q-}. Q stands for a bivalent group selected from -CF_2-CH_2O- and -CH_2-CH_2O-. These groups comprise an ether-group, and are therefore considered part of the PFPE moiety according to claim 1. The oxygen atom of Q is the oxygen atom that ultimately terminates the PFPE moiety;

2) **The non-oxygen containing spacer is represented by B.** The expression "non-oxygen containing" means that there is no oxygen atom whatsoever in the spacer, not in the "backbone," nor in the possible "branches." That the spacer extends over at least three atoms means that there are at least three atoms in a row between the terminating oxygen atom and the ethylenically unsaturated group (see the application as filed on page 2, lines 29-31).

3) **The ethylenically unsaturated group is represented by A.**

The scope of protection as elucidated above will now be used to prove that the Examiner's objections are based on an incorrect interpretation of the claims in the present application.

Concerning the Examiner's novelty rejection, it is the Applicants' position that none of the disclosed structures satisfy all of the requirements mentioned above. As proof of this position, copies of the relevant pages of both US 5,837,774 and US 6,673,887, with written comments thereon are provided in Appendix 1 and 2 attached hereto.. In all cases the ultimately terminating oxygen atoms are indicated with an arrow, the spacer with brackets and the ethylenically unsaturated group with parentheses {}. In the sense of the present application, the ethylenically unsaturated group may comprise $-SiCH_3)_2-$ (see claim 4) and is therefore not considered part of the spacer.

In paragraph 11 of the Office Action the Examiner states that the current broad scope of claim 1 allows the ethylenically unsaturated group to contain oxygen, e.g., $-O-CH_2-CH=CH_2$ (see formulas #2 in Tarumi and Yamaguchi). This position of the Examiner is traversed because a skilled person would consider the oxygen atom of the group $-O-CH_2-CH=CH_2$ to be the ultimately terminating oxygen atom of the PFPE moiety, based on claim 1 of the present invention. This leaves the $-CH_2-$ to be the spacer and $CH=CH_2$ the ethylenically unsaturated group. However, if the interpretation of the Examiner is followed, one does not arrive at the present invention of claim 1. Therefore, even in the broad interpretation of claim 1, none of the disclosed compounds comprise a non-oxygen containing spacer that extends over sat least 3 atoms (both formulas #2 in Tarumi and Yamaguchi extend over 2 atoms, if the ethylenically unsaturated group is represented by $-O-CH_2-CH=CH_2$.

Concerning the Examiner's obviousness rejection, it is the Applicants' position that none of the previously mentioned documents hints at non-oxygen containing spacers extending over at least 3 atoms. This characteristic is an essential and distinguishing feature of the present invention which would not be obvious to one skilled in the art from the cited documents, either alone or in combination. Thus, as can be seen by referring to page 2, lines 24-31 of the present application, it has been surprisingly found that rubbers having good visco-elastic properties, including high elasticity and low compression set can be achieved when the spacer of the cross-linkable compound of the present invention extends over at least three atoms between the oxygen atom and the ethylenically unsaturated group. Accordingly, the distance between the oxygen

atom which terminates the compound comprising the PFPE-moiety and the ethylenically unsaturated group involves at least three atoms in a row. As a result, good monomers for providing effective rubbers can be obtained.

Accordingly, in view of the above amendments and remarks, reconsideration of the rejections and allowance of all of the claims of the present application are respectfully requested. In the event that the present proposed Amendment does not place the present application into condition for allowance, entry thereof is respectfully requested as placing the present application into better condition for appeal.

Should there be any outstanding matters that need to be resolved in the present application, the Examiner is respectfully requested to contact Joseph A. Kolasch Reg. No. 22,463 at the telephone number of the undersigned below, to conduct an interview in an effort to expedite prosecution in connection with the present application.

If necessary, the Commissioner is hereby authorized in this, concurrent, and future replies to charge payment or credit any overpayment to Deposit Account No. 02-2448 for any additional fees required under 37.C.F.R. §§1.16 or 1.14; particularly, extension of time fees.

Dated: January 7, 2008

Respectfully submitted,

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Attachments: Appendix 1 and 2

Annex 1 : US 5,837,774 ; Tarumi et al. p 1/2

CURABLE FLUOROPOLYETHER RUBBER COMPOSITION

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a curable fluoropolyether rubber composition capable of producing a cured product excellent in water repellency, oil repellency, solvent resistance, chemical resistance, weatherability, releasability, lubricating qualities and the like.

2.Description of the Prior Art

Industrially produced fluorine-containing polymer materials are broadly employed as resins, rubbers, coating agents, paints, various film materials, and the like, because of fluorine's excellent properties such as heat resistance, chemical resistance, solvent resistance, releasability, lubricating qualities, water repellency, oil repellency, and weatherability. However, these properties don't appear necessarily in all types of fluorine-containing polymer materials. For example, polytetrafluoroethylene, which is the most typical material of fluorine-containing polymer materials, has all the above characteristics, but there is known no fluorine-containing rubbers having all these properties.

Further, vinylidene fluoride-hexafluoropropylene (or additionally -tetrafluoroethylene) rubbers are inferior in resistance to strongly polarized solvents or chemicals and poor in surface characteristics, such as releasability and lubricating qualities, and resistance to low temperatures required sometimes for rubber materials. Similarly, even so-called perfluororubbers, which are tetrafluoroethylene-perfluoroalkyl vinyl ether, are poor in releasability, lubricating qualities, processing characteristics, and the like.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a curable fluoropolyether rubber composition capable of producing fluororubbers well-balanced in and excellent in properties such as heat resistance, chemical resistance, solvent resistance, releasability, lubricating qualities, water repellency, oil repellency and weatherability.

The present invention provides a curable fluoropolyether rubber composition comprising:

(A) a straight chain fluoropolyether compound having at least two alkenyl groups in its molecule and having a divalent perfluoropolyether structure in its backbone chain,

(B) a polytetrafluoroethylene,

(C) an organohydrogenpolysiloxane having at least two hydrogen atoms bonded to silicon atoms in its molecule, and

(D) a hydrosilylation reaction catalyst.

The composition of this invention is in the form of a paste capable of forming readily into any desired shapes, and its cured product is well-balanced in and is excellent in properties such as heat resistance, chemical resistance, solvent resistance, releasability, lubricating qualities, water repellency, oil repellency and weatherability.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is hereinafter described in detail.

Component (A): straight chain polyether compound

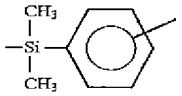
The straight chain fluoropolyether compound used in this invention has a divalent perfluoropolyether structure in its backbone chain. The perfluoropolyether structure includes, for example, ones represented by the following general formula (2):

$$-(Rf-O)_q- \quad (2)$$

wherein Rf is a straight chain or branched perfluoroalkylene group having 1 to 6 carbon atoms, preferably 1 to 3 carbon atoms, and q is an integer of 1 to 500, preferably 2 to 400, more preferably 10 to 200.

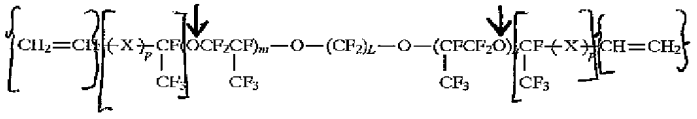
The repeating unit represented by said —(Rf—O)— includes, for example, $-CF_2O-$, $-CF_2CF_2O-$, $-CF_2CF_2CF_2O-$, $-CF(CF_3)CF_2O-$, $-CF_2CF_2CF_2CF_2O-$, $-CF_2CF_2CF_2CF_2CF_2CF_2O-$ and $-C(CF_3)_2O-$; among which preferred are $-CF_2O-$, $-CF_2CF_2O-$, $-CF_2CF_2CF_2O-$ and $-CF(CF_3)CF_2O-$. Said perfluoropolyether structures may be comprised of one of the repeating units represented by these —(Rf—O)— or a combination of two or more thereof.

The alkenyl group contained in the straight chain fluoropolyether compound of said component (A) includes, for example, that having a $CH_2=CH-$ structure at the ends, such as vinyl, allyl, propenyl, isopropenyl, butenyl, and hexenyl groups, preferably vinyl and allyl groups. The alkenyl group may be bonded directly to both ends of the backbone chain of the straight chain fluoropolyether compound or may be bonded through a divalent connecting group such as $-CH_2-$, $-CH_2O-$, or —Y—NR—CO— wherein Y is $-CH_2-$ or a group represented by the formula:



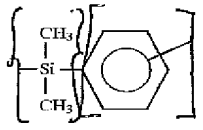
(o-, m- or p-position), and R is a hydrogen atom, a methyl group, a phenyl group or a allyl group.

Typical examples of the straight chain fluoropolyether compound used in the present invention include, for example, a fluoropolyether compound having a molecular weight of 400 to 100,000, preferably 1,000 to 50,000, represented by the following general formula (1):



(1)

wherein X are independently $-CH_2-$, $-CH_2O-$ or —Y—NR—CO— wherein Y is $-CH_2-$ or a group represented by the formula:



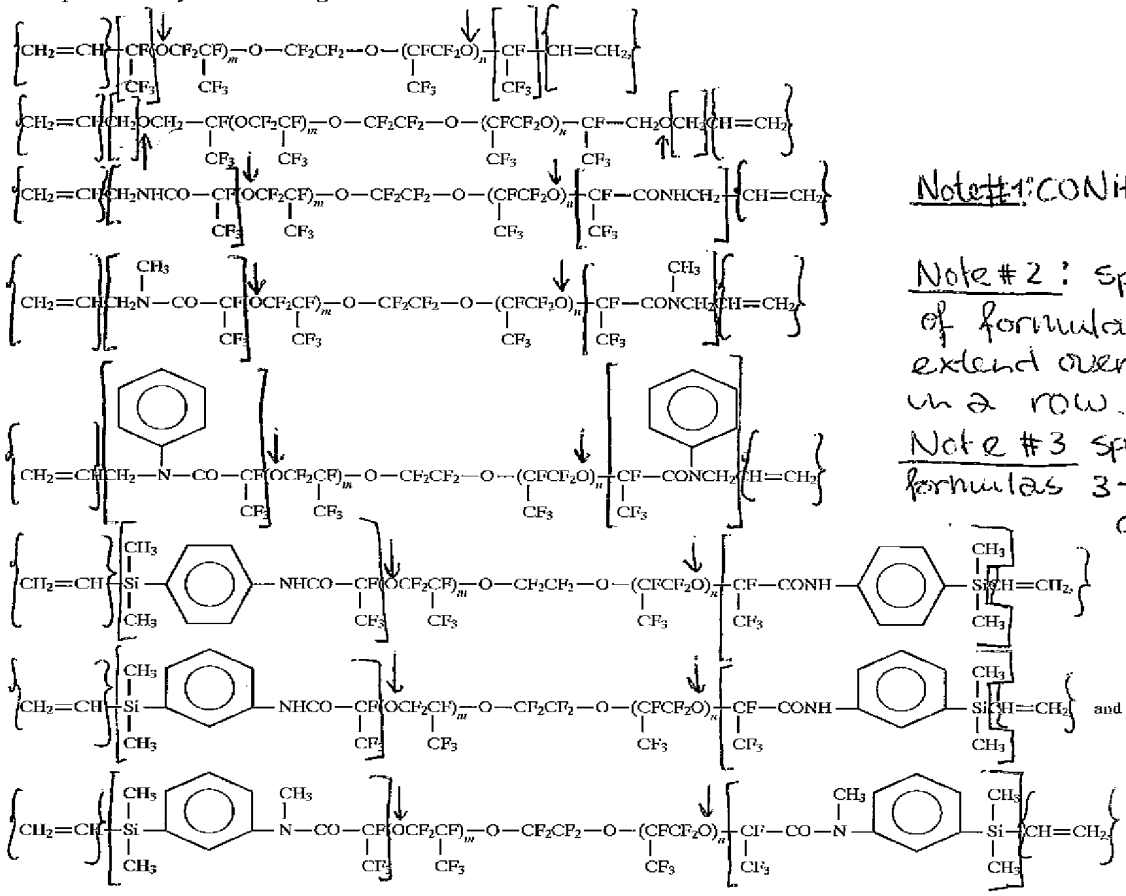
according to claim 4 of present invention $-Si(CH_3)_2-$ is part of ethylenically unsaturated group; phenyl is part of spacer

(o-, m- or p-position), and R is a hydrogen atom, a methyl group, a phenyl group or an allyl group; p are independently

Annex 1: US 5,837,774 ; Tarumi et al. p 2/2

0 or 1, L is an integer of 2 to 6, and m and n are each an integer of 0 to 200, preferably 5 to 100. Specific examples of the fluoropolyether compound represented by the general formula (1) include straight chain fluoropolyether compounds represented by the following formulas:

#1 #2 #3 #4 #5 #6 #7 #8



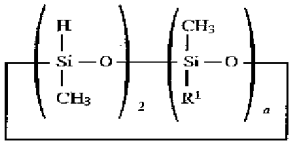
Note#1: CONH ≡ -C(=O)-N(H)-

Note#2: Spacers of formulas 1 and 2 extend over 1 atom in a row.

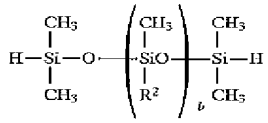
Note #3 spacers of formulas 3-8 all contain oxygen

wherein m and n are each as defined in the above formula (1).

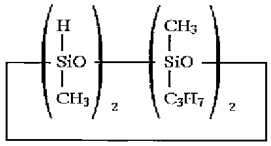
Further, in order to previously adjust the molecular weight of the straight chain fluoropolyether compound to a desired value depending upon its uses, the component (A) may be a chain-extended product obtained by subjecting a straight chain fluoropolyether compound having said general formula (1) and an organosilicon compound having two SiH groups in its molecule to hydrosilylation reaction to thereby extend the chain length of the fluoropolyether compound. Examples of the organosilicon compound having two SiH groups in its molecule include a straight chain or cyclic organohydrogenpolysiloxane such as a compound represented by the following formula:



wherein R^1 is a methyl group, an ethyl group, a propyl group or a 3,3,3-trifluoropropyl group, and a is 1 or 2; and a compound represented by the following formula:



wherein R^2 is a methyl group or a 3,3,3-trifluoropropyl group, and b is an integer of 0 to 6; and preferably a compound represented by the following formula:



A reaction product obtained by reacting at least one of these compounds with, for example, a compound represented by the formula (1) so that the product has a desired chain length, may be also used as the component (A). For example, there is enumerated a reaction product obtained by a reaction represented by the following formulas:

CURED FLUORINE-CONTAINING MATERIAL

[0001] This invention relates to cured fluorine-containing materials having a refractive index of up to 1.335 at 25° C. and best suited as optical materials such as antireflection films as well as rubber materials, tent film materials, sealants, coating materials, and parting agents where solvent resistance is required.

BACKGROUND OF THE INVENTION

[0002] Heretofore, curable fluorine-containing compositions primarily comprising a polymer of fluorine-containing organic compound and a crosslinking agent have been used in a variety of applications.

[0003] With the rapid development of the information society, large size displays of the liquid crystal, CRT, plasma and other systems are on widespread use. Those displays, especially of the portable type, used outdoor or in an illuminated space are required to improve their recognition capability. One common means for improving the recognition capability is to provide the substrate of a display device with an antireflection film of low refractive index materials, typically fluorine compounds. Such antireflection films are formed by vacuum evaporating inorganic materials or by depositing alternating films of high and low refractive index materials, which techniques lack productivity.

[0004] Known low refractive index materials which can be coated have a refractive index of 1.34 at the lowest. There is a need for a material having a lower refractive index.

SUMMARY OF THE INVENTION

[0005] An object of the invention is to provide a cured fluorine-containing material having a sufficiently low refractive index to be used as an antireflection film or the like.

[0006] It has been found that a curable composition comprising (A) a linear fluoropolyether compound having at least two alkenyl groups per molecule and a perfluoroalkyl ether structure in the backbone, (B) a fluorine-containing organohydrogensiloxane, and (C) a platinum group catalyst can be coated in solution form and converted, by holding at room temperature or heating, into a cured thin film comprising a perfluoropolyether backbone and having a refractive index of up to 1.335 at 25° C., especially when the fluorine content in the cured film is at least 61.0% by weight.

[0007] Briefly stated, the invention provides a cured fluorine-containing material comprising as the backbone a perfluoropolyether of the following general formula (1):

$$-(Rf-O)_q- \quad (1)$$

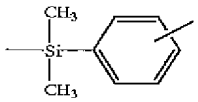
[0008] wherein Rf is a perfluoroalkylene group of 1 to 6 carbon atoms and q is a number of 1 to 500, and having a refractive index of up to 1.335 at 25° C.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0009] The cured fluorine-containing material of the invention is obtained by curing a curable composition comprising (A) a linear fluoropolyether compound having at least two alkenyl groups per molecule and a perfluoroalkyl ether structure of the formula (1) in the backbone, (B) a fluorine-containing organohydrogensiloxane, and (C) a platinum group catalyst.

[0010] The linear fluoropolyether compound (A) should have at least two alkenyl groups per molecule and a perfluoroalkyl ether structure in the backbone. It is used as a base polymer in the composition.

[0011] The alkenyl groups in the linear fluoropolyether compound are, for example, groups having a CH_2═CH— structure at the terminus such as vinyl, allyl, propenyl, isopropenyl, butenyl and hexenyl, and preferably vinyl and allyl. The alkenyl groups may be attached to the backbone of linear fluoropolyether compound at opposite ends directly or through divalent linking groups such as —CH_2—, —CH_2O— or —Y— NR—CO—. Herein Y is —CH_2— or



[0012] (wherein the free valence bond may be at an o-, m- or p- position), and R is hydrogen, methyl, phenyl or allyl.

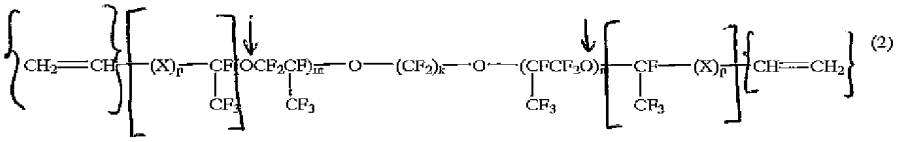
[0013] The perfluoroalkyl ether structure in the linear fluoropolyether compound is of the general formula (1) as mentioned above.

$$-(Rf-O)_q- \quad (1)$$

[0014] Rf is a straight or branched perfluoroalkylene group of 1 to 6 carbon atoms, preferably 1 to 3 carbon atoms, and q is an integer of 1 to 500, preferably 2 to 400, and more 3preferably 10 to 200.

[0015] Examples of the recurring units represented by —(Rf—O)— include —CF_2—, —CF_2CF_2O—, —$CF_2CF_2CF_2O$—, —$CF(CF_3)CF_2O$—, —$CF_2CF_2CF_2CF_2O$—, —$CF_2CF_2CF_2CF_2CF_2CF_2O$—, and —$C(CF_3)_2O$—. Preferred among these are —CF_2—, —CF_2CF_2O—, —$CF_2CF_2CF_2O$—, and —$CF(CF_3)CF_2O$—. Especially preferred are perfluoropolyethers comprising recurring units of hexafluoropropenoxide. The perfluoroalkyl ether structure may consist of one or more types of recurring units represented by —(Rf—O)—.

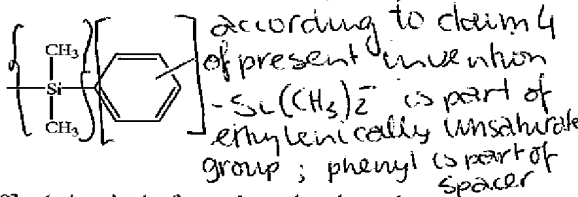
[0016] Examples of the linear fluoropolyether compound (A) are linear fluoropolyether compounds of the following general formula (2):



(2)

Annex 2 : US 6,673,887; Yamaguchi et al. p 2/2

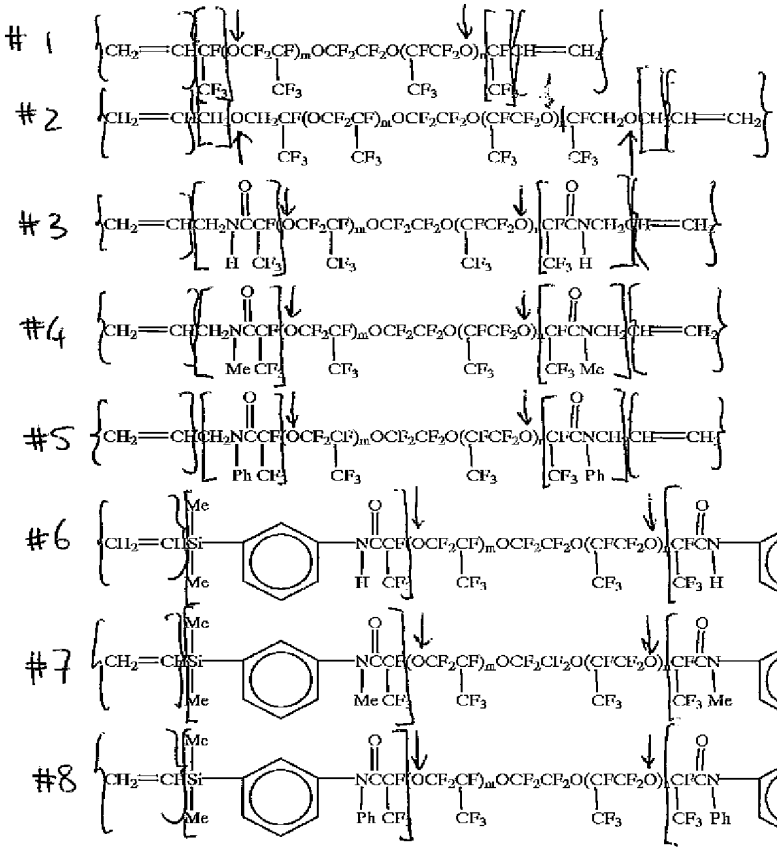
[0017] wherein X is independently —CH_2—, —CH_2O—, or —Y—NR—CO—, Y is —CH_2— or



according to claim 4 of present invention -Si$(CH_3)_2$- is part of ethylenically unsaturated group ; phenyl is part of spacer

[0018] (wherein the free valence bond may be at an o-, m- or p- position), R is hydrogen, methyl, phenyl or allyl, p is independently 0 or 1, k is an integer of 2 to 6, m and n each are an integer of 0 to 200, preferably 5 to 150, and having a weight average molecular weight of about 400 to 100,000, preferably about 2,000 to 50,000.

[0019] Illustrative, non-limiting examples of the linear fluoropolyether compound (A) are shown below.



Note #1 : spacers of formulas 1 and 2 extend over 1 c-atom
note # 2 : spacers of formulas 3-8 all contain oxygen

[0020] In the above formulas, m and n are as defined in formula (1), Me is methyl and Ph is phenyl.

[0021] These linear fluoropolyether compounds may be used alone or in admixture of two or more.

[0022] The linear fluoropolyether compound (A) used herein may range from a low viscosity polymer having a viscosity of several ten centistokes at 25° C. to a solid gum-like polymer. From the ease of handling standpoint, polymers having a viscosity of about 1,000 to 100,000 centistokes at 25° C. are advantageously used for coating purposes. Polymers having a too low viscosity may result in cured films having reduced film strength and/or adhesion, failing to provide a good profile of physical properties.

[0023] The fluorine-containing organohydrogensiloxane (B) serves as a crosslinking agent or chain extender for the linear fluoropolyether compound (A). The fluorine-containing organohydrogensiloxane is not critical as long as it has at least one monovalent perfluoroalkyl group, monovalent perfluorooxyalkyl group, divalent perfluoroalkylene or divalent perfluorooxyalkylene group and at least two, preferably at least three hydrosilyl groups, i.e., Si—H groups in a molecule. The perfluoroalkyl, perfluorooxyalkyl, perfluoroalkylene and perfluorooxyalkylene groups are exemplified by the groups of the following general formulae.

[0024] monovalent perfluoroalkyl groups:

$$C_pF_{2p+1}—$$

[0025] Letter p is an integer of 1 to 20, preferably 2 to 10. divalent perfluoroalkylene groups:

$$—C_pF_{2p}—$$

[0026] Letter p is an integer of 1 to 20, preferably 2 to 10. monovalent perfluorooxyalkyl groups: